

Evaluation of the Noah-MP LSM coupled to WRF in a semiarid urban environment

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- Introduction
- WRF-simulations
- Results (WRF vs Observations):
 - Rural areas (near-surface temp. and wind speed)
 - Urban areas (near-surface temp. and wind speed)
 - Urban and rural areas (daytime land surface temp.)
- Conclusions

Introduction

- We have augmented the existing capabilities of the WRF-urban modeling system by coupling three UCMs with the new community Noah with multi-parameterization options (Noah-MP) LSM.
- These new WRF-urban modeling system's capabilities are included in the public release of WRF and are available in WRFv3.9 (April 2017).

WRF-simulations

WRF-simulations	Land surface model	Urban parameterization
Noah-BULK	Noah	Bulk
Noah-SUCM	Noah	Single-layer UCM
Noah-BEPBEM	Noah	Multilayer BEP+BEM
NoahMP-BULK	Noah-MP	Bulk
NoahMP-SUCM	Noah-MP	Single-layer UCM
NoahMP-BEPBEM	Noah-MP	Multilayer BEP+BEM

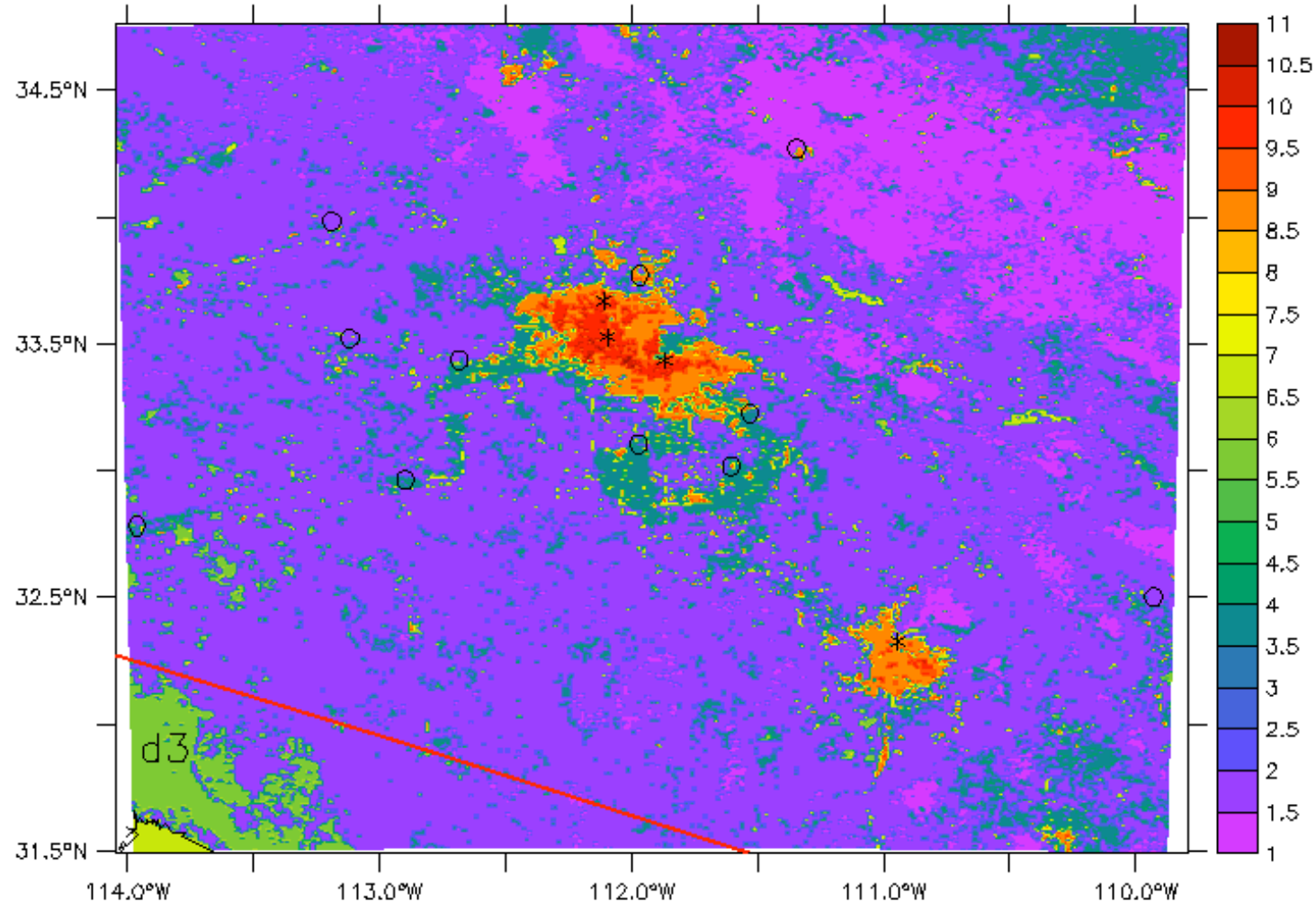
WRF-simulations

- WRF-model (V3.7.1) simulations were performed with three two-way nested domains with 276 x 296, 250 x 283, and 391 x 364 grid points, distanced, 9, 3, and 1 km respectively (the number of vertical sigma pressure levels was 40).
- The simulations were conducted with the National Centers for Environmental Prediction Final Analysis data files (number ds083.2) for a 15-day clear-sky summertime period from June 15 (00 LT) to June 29 (23 LT) 2012.
- The US Geological Survey 30m 2006 National Land Cover Data set was used to represent modern-day LULC within the Noah and Noah-MP land surface models for the urban domain. Three different urban classes describe the morphology of the cities: COI, HIR and LIR.

MODIS-based LULC and urban classification in the inner domain. AZMET weather stations locations for WRF model evaluation are indicated in the map

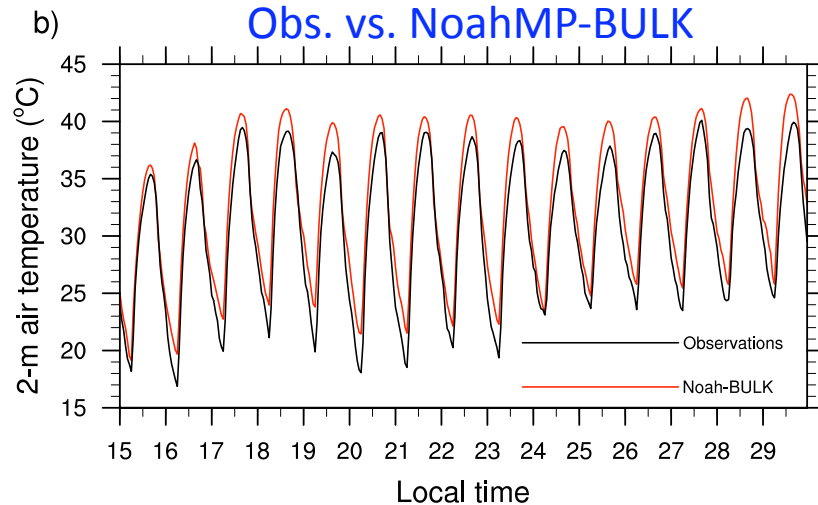
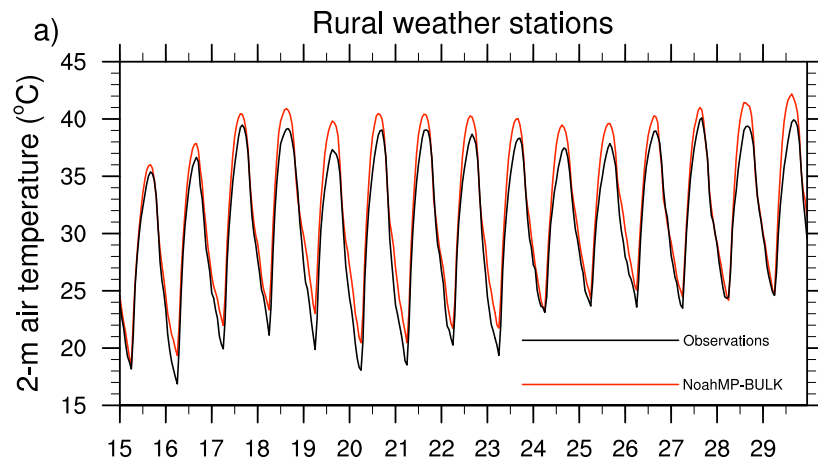
MODIS-based LULC and urban classification (shaded based on Fry et al., 2011)

AZMET weather stations: 11 rural (o) and 4 urban (*) for WRF model evaluation

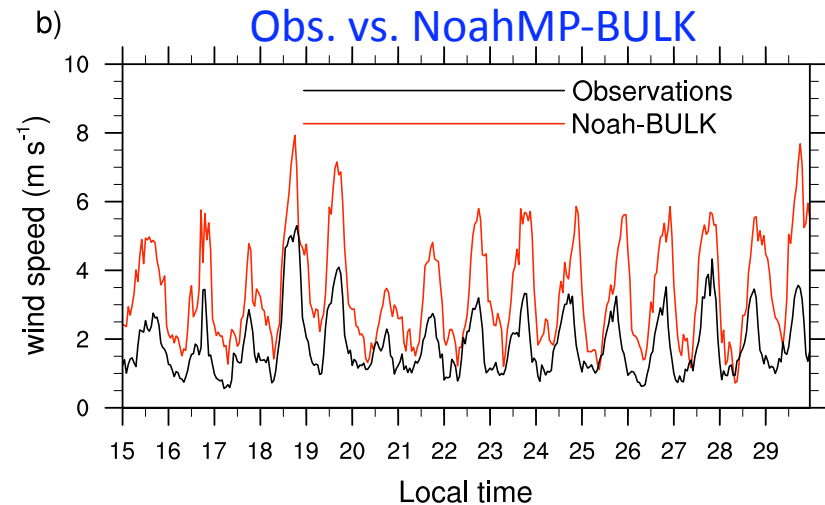
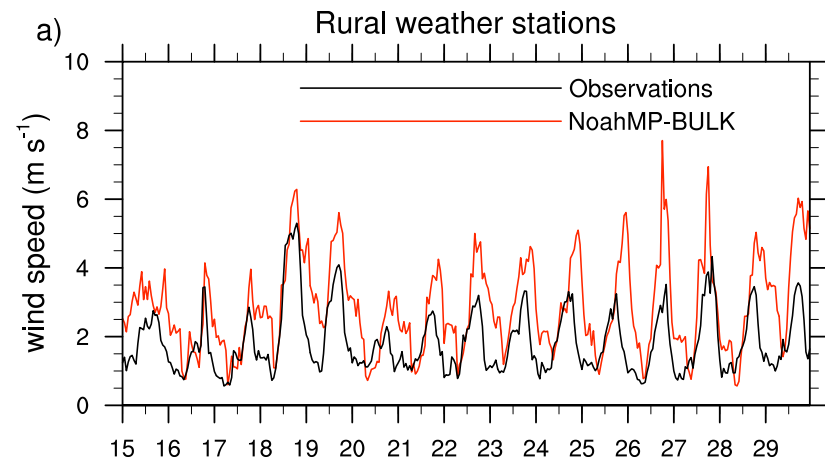


- 1: Forests, 2: Shrublands, 3: Savannas, 4: Wetlands/Croplands/Grasslands
5: Snow/Ice, 6: Barren/Sparsely vegetated, 7: Water, 8: Tundra
9: Urban (LIR), 10: Urban (HIR), 11: Urban (COI)

Time series of observed (black curves) and WRF-modeled (red curves) 2-m air temperature (left) and 10-m wind speed (right) averaged over all rural stations

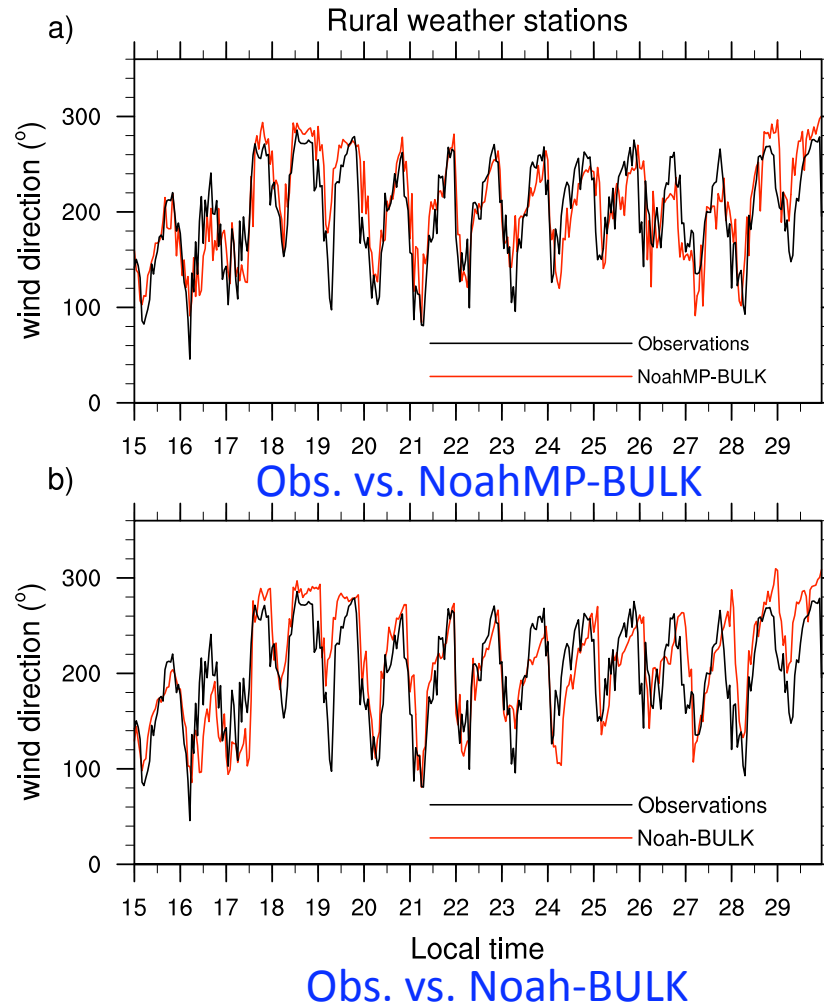


Obs. vs. Noah-BULK

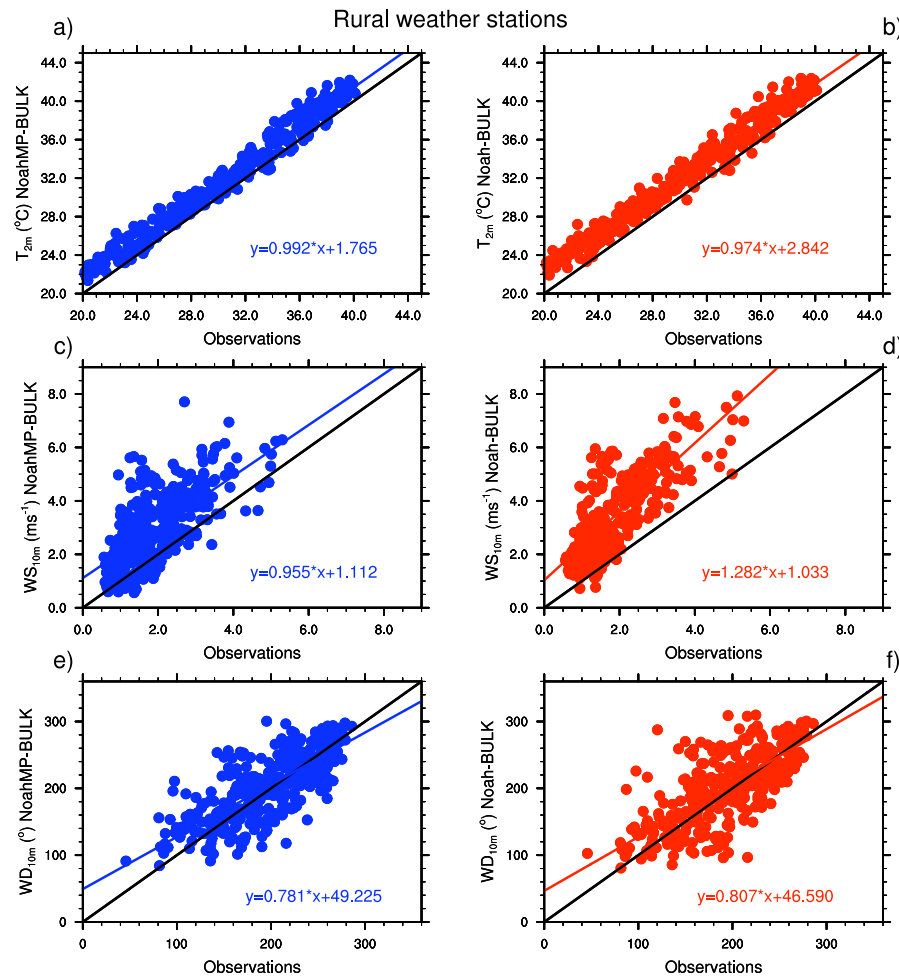


Obs. vs. Noah-BULK

Time series of observed (black curves) and WRF-modeled (red curves) 10-m wind direction averaged over all rural stations



Scatter plots of WRF-modeled vs observed 2-m air temperature (top), 10-m wind speed (middle) and 10-m wind direction (bottom) averaged over all rural stations



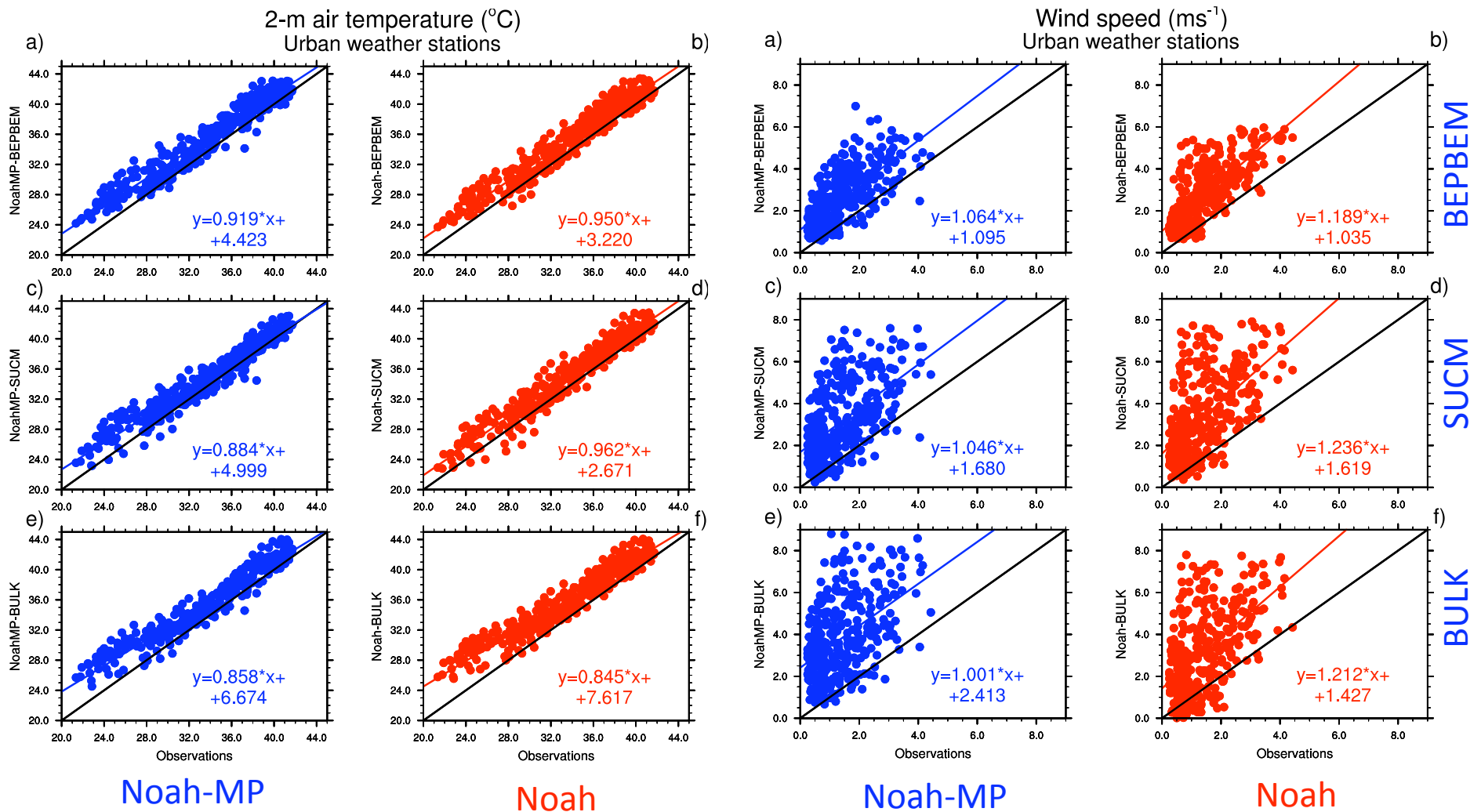
NoahMP-BULK vs Obs.

Noah-BULK vs Obs.

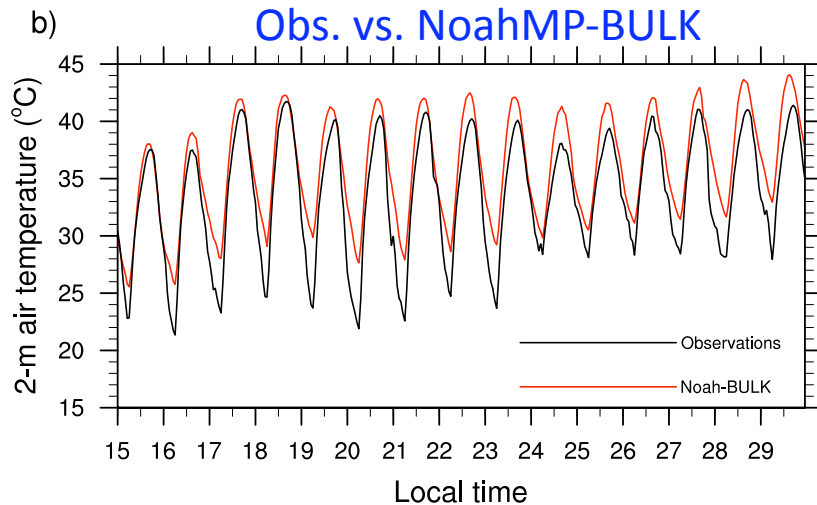
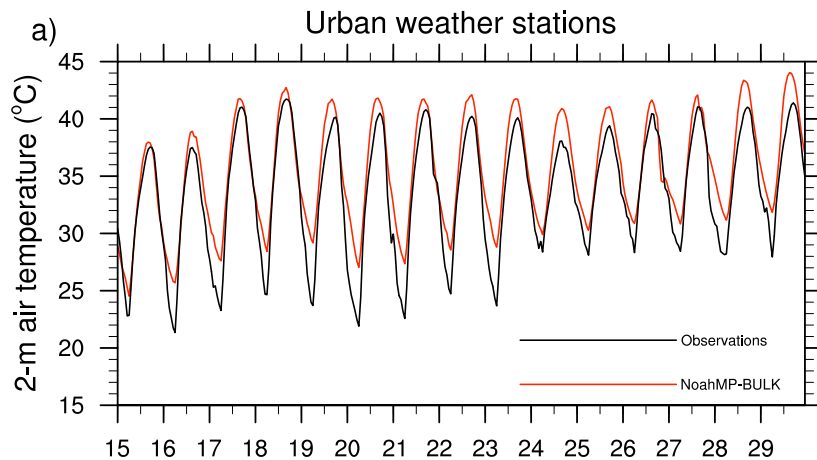
RMSE and MAE for WRF-modeled 2-m air temperature ($^{\circ}\text{C}$) and 10-m wind speed (ms^{-1}) at the rural stations

WRF-experiment	RMSE ($^{\circ}\text{C}$)	MAE ($^{\circ}\text{C}$)	RMSE (ms^{-1})	MAE (ms^{-1})
NoahMP-BEPBEM	1.772	1.529	1.361	1.082
Noah-BEPBEM	2.113	1.915	1.851	1.602
NoahMP-SUCM	1.780	1.543	1.388	1.098
Noah-SUCM	2.091	1.887	1.913	1.657
NoahMP-BULK	1.774	1.548	1.435	1.137
Noah-BULK	2.248	2.056	1.828	1.563

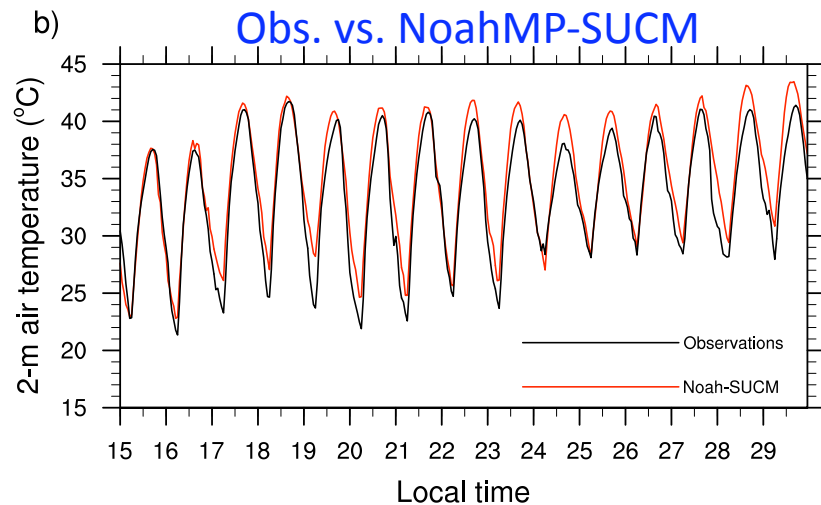
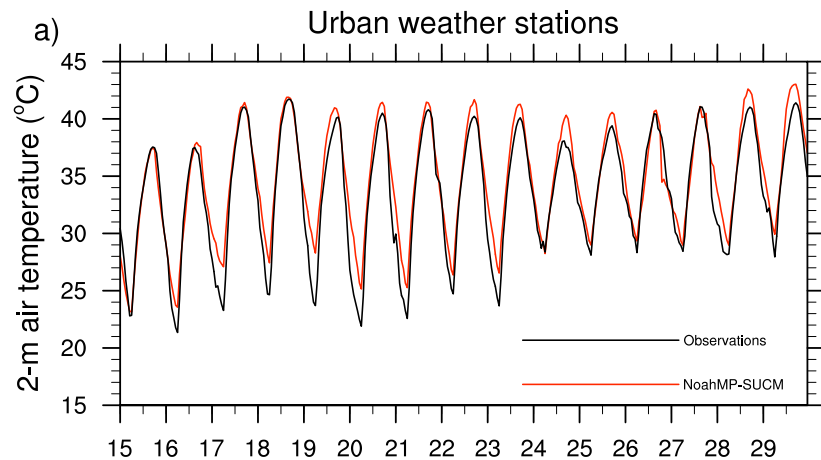
Scatter plots of WRF-modeled vs observed 2-m air temperature (left) and 10-m wind speed (right) averaged over all urban stations



Time series of observed (black curves) and WRF-modeled (red curves) 2-m air temperature averaged over all urban stations

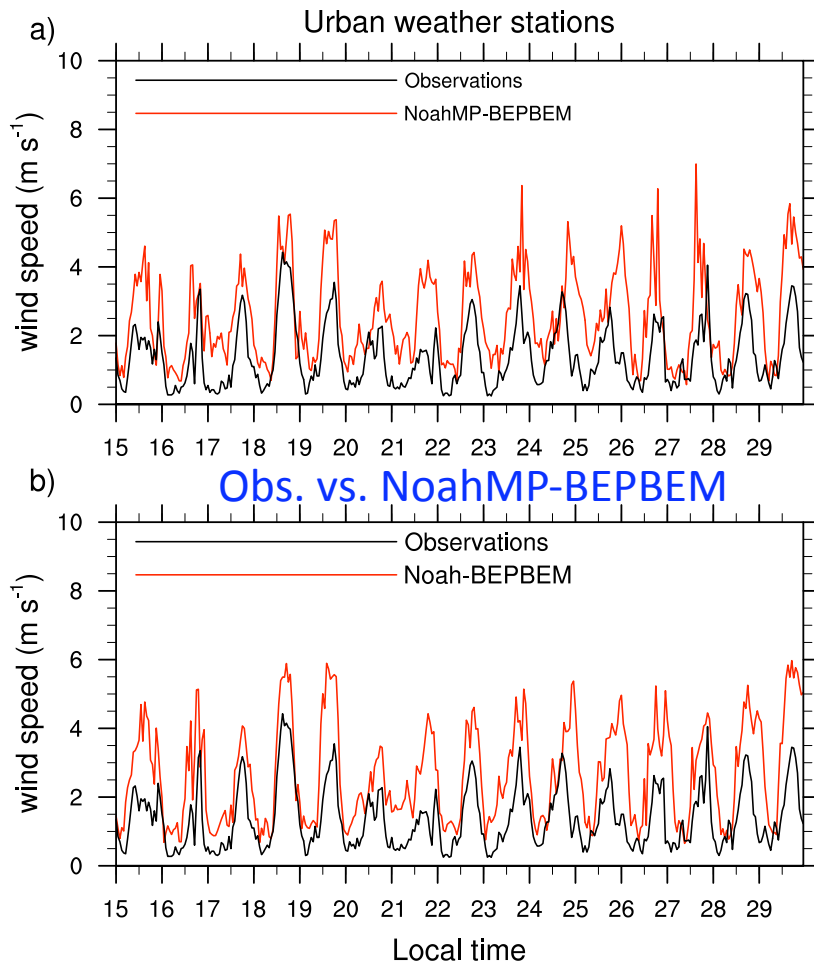


Obs. vs. Noah-BULK

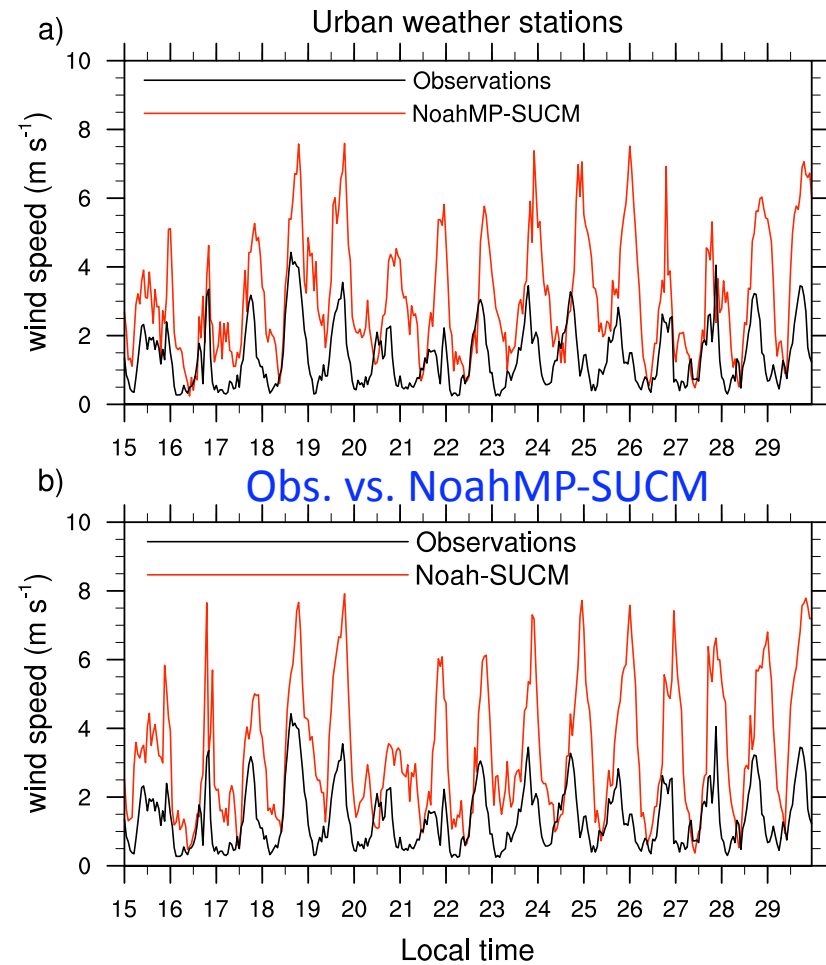


Obs. vs. Noah-SUCM

Time series of observed (black curves) and WRF-modeled (red curves) 10-m wind speed averaged over all urban stations

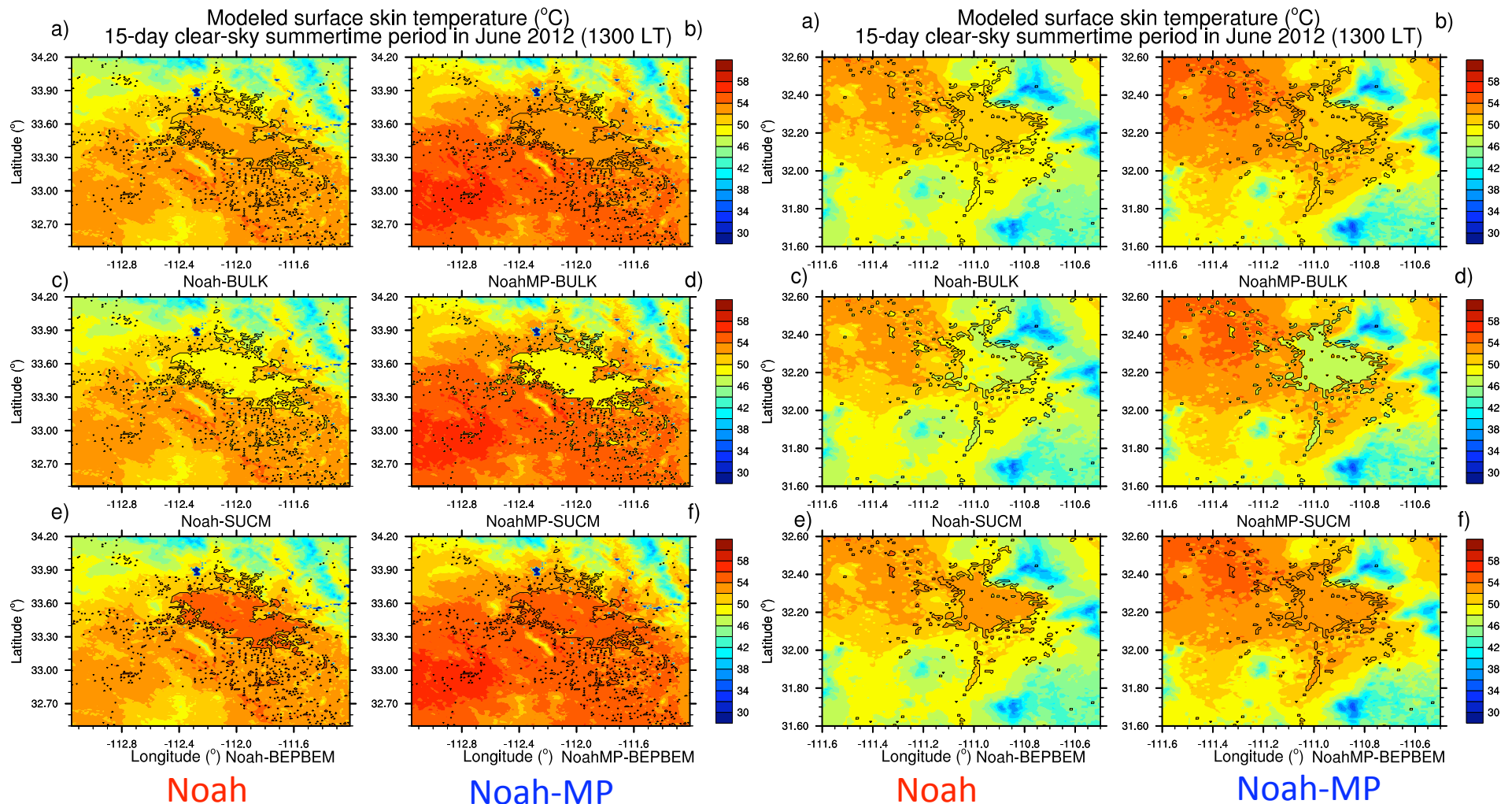


Obs. vs. Noah-BEPBEM

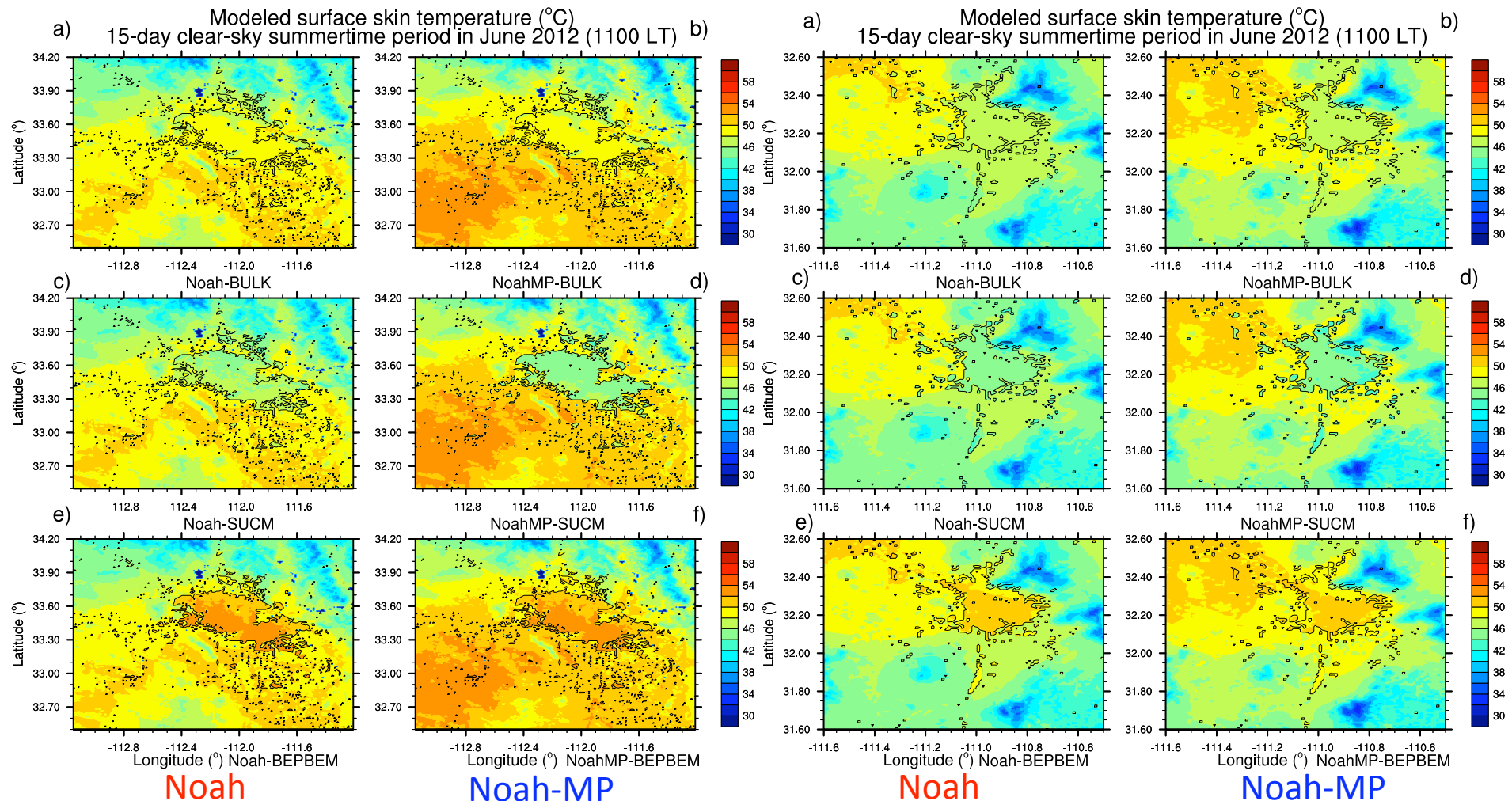


Obs. vs. Noah-SUCM

WRF-modeled mean surface skin temperature averaged for the entire 15-day clear-sky summertime period (at 1300 LT) and across the Phoenix (left) and Tucson (right) regions



WRF-modeled mean surface skin temperature averaged for the entire 15-day clear-sky summertime period (at 1100 LT) and across the Phoenix (left) and Tucson (right) regions



Spatial mean of daytime MODIS-observed and WRF-modeled surface skin temperature averaged for the entire 15-day clear sky summertime period (at 1100 LT and at 1300 LT) and across the Phoenix (PHX) and Tucson (TUC) regions

WRF-experiments	PHX (°C) (1300 LT)	TUC (°C) (1300 LT)	PHX (°C) (1100 LT)	TUC (°C) (1100 LT)
NoahMP-BEPBEM	52.986	50.109	49.437	46.878
Noah-BEPBEM	50.908	48.663	48.004	46.073
NoahMP-SUCM	52.296	49.534	48.756	46.292
Noah-SUCM	50.289	48.156	47.355	45.544
NoahMP-BULK	52.671	49.842	48.998	46.537
Noah-BULK	50.622	48.430	47.619	45.771
MODIS	55.224	53.932	51.808	49.553

Salamanca et al. (2017), J. Geophys. Res. Atmos. (submitted)

Conclusions

- Noah-MP reproduces somewhat better than Noah the daytime surface skin temperature and the daily evolution of near-surface air temperature and wind speed.
- Bulk urban parameterization seems to overestimate nighttime 2-m air temperature compared to the single-layer and multilayer UCMs that reproduce more accurately the daily evolution of near-surface air temperature.
- Only the multilayer UCM is able to reproduce effectively the daily evolution of near-surface wind speed, while both the single-layer and bulk urban parameterizations overestimate it considerably.